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PROBLEMATIC ASPECTS OF STRING THEORIES AND THEIR POSSIBLE RESOLUTION

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Abstract

We identify new, rather serious, physical and axiomatic inconsistencies of the current formulation of string theories due to the lack of invariant units necessary for measurements, lack of preservation in time of Hermiticity-observability, and other shortcomings. We propose three novel reformulations of string theories for *matter* of progressively increasing complexity via the novel iso-, geno- and hyper-mathematics of hadronic mechanics, which resolve the current inconsistencies, while offering new intriguing possibilities, such as: an axiomatically consistent and invariant formulation on curved manifolds, the reduction of macroscopic irreversibility to the most primitive level of vibrations of the universal substratum (ether), or the treatment of multi-valued biological structures. We then identify three corresponding *classical* formulations of string theories for *antimatter* via the novel anti-isomorphic isodual mathematics. We finally outline the intriguing features of the emerging new cosmologies (including biological structures, as it should be for all cosmologies), such as: universal invariance (rather than covariance) under a symmetry isomorphic to the Poincaré group and its isodual; equal distributions of matter and antimatter in the universe (as a limit case); continuous creation; no need for the missing mass; significantly reduced dimensions; possibility of experimental identification of matter and antimatter in the universe; and identically null total characteristics of time, energy, linear and angular momentum, charge, etc.

As it is well known, the origin of the physical consistency of relativistic quantum mechanics (RQM) is its Lie structure, which we express for subsequent needs with the following finite form, infinitesimal version and conjugation,

$$A(w) = U \times A(0) \times U^\dagger = e^{iX \times w} \times A(0) \times e^{-iw \times X} = e_{>}^{iX > w} > A(0) < e_{<}^{-iw < X},$$

$$idA/dw = A \times X - X \times A = A < X - X > A,$$

$$e_{>}^{iX>w} = [e_{<}^{-iw<X}]^\dagger, \quad (1)$$

realized via *unitary transformations* defined on a Hilbert space \mathcal{H} over the field $C(c, +, \times)$ of complex numbers c with conventional sum $+$ and associative) product \times .

In fact, the unitary structure implies the following well known basic invariances:

$$\begin{aligned} U \times U^\dagger &= U^\dagger \times U = I, \\ I &\rightarrow U \times I \times U^\dagger = I' = I, \\ A \times B &\rightarrow U \times (A \times B) \times U^\dagger = (U \times A \times U^\dagger) \times (U \times B \times U^\dagger) = A' \times B', \\ H \times |\psi > &= E \times |\psi > \rightarrow U \times H \times |\psi > = (U \times H \times U^\dagger) \times (U \times |\psi >) = H' \times |\psi' > = \\ &U \times E \times |\psi > = E' \times |\psi' >, E' = E. \end{aligned} \quad (2)$$

It then follows that *all theories with a unitary structure defined on a Hilbert space over the field of complex numbers possess numerically invariant units, products and eigenvalues, thus being suitable to represent physical reality.*

By comparison, theories with a *nonunitary structure* have serious flaws studied in details in Refs. [1], because invariances (2) are turned into the following noninvariances,

$$\begin{aligned} U \times U^\dagger &= U^\dagger \times U \neq I, \\ I &\rightarrow U \times I \times U^\dagger = I' \neq I, \\ A \times B &\rightarrow U \times (A \times B) \times U^\dagger = (U \times A \times U^\dagger) \times (U \times U^\dagger)^{-1} \times (U \times B \times U^\dagger) = A' \times T \times B', T = (U \times U^\dagger)^{-1}, \\ H \times |\psi > &= E \times |\psi > \rightarrow U \times H \times |\psi > = (U \times H \times U^\dagger) \times (U \times U^\dagger)^{-1} \times (U \times |\psi >) = \\ &H' \times T \times |\psi' > = U \times E \times |\psi > = E' \times |\psi' >, E' \neq E, \end{aligned} \quad (3)$$

which imply rather serious *physical inconsistencies*, such as: the lack of invariance of the basic units of time, space, energy, etc, which is necessary for consistent measurements; the lack of preservation in time of Hermiticity, which is necessary to have physically acceptable observables; lack of uniqueness and invariance in time of the physical predictions of the theory, and other flaws (for details, see Refs. [1]).

Invariances (3) also have seemingly catastrophic axiomatic inconsistencies at both classical and operator levels. Recall that all axiomatic structures of physical theories (such as vector and metric spaces, functional analysis, algebras and groups, etc.) are formulated over a given field of numbers which, in turn, is crucially dependent on the unit. The alteration in time of the basic unit then implies the loss of the original field at subsequent times. This is due to the fact that the noncanonical-nonunitary transform must be applied, for consistency, to the *totality* of the original structure (see below), including numbers, and cannot be applied only to part of the original structure to please personal preferences. However, noncanonical-nonunitary theories continue to be generally expressed over the original field. The lack of invariance of the basic unit then implies the inapplicability of the entire axiomatic structure

of noncanonical-nonunitary theories without any exception known to this author (for details see Refs. [1g,3g]).

The above physical and axiomatic inconsistencies reach their climax for all theories formulated on a *curved manifold* [1g,3g]. In fact, the map from the Minkowski metric $\eta = \text{diag.}(1, -1, -1, -1) = \text{constant}$ to a Riemannian metric $g(x) = \text{function}$ is transparently a *noncanonical transform*, $\eta \rightarrow g(x) = U(x) \times \eta \times U^t(x)$, $U(x) \times U^t(x) \neq I$. Operator theories on curved manifolds must then be necessarily nonunitary. As a result, the above physical and axiomatic inconsistencies hold at both classical and operator levels (see also [1g,3g] for brevity).

We therefore have the following

THEOREM 1 [1]: All operator theories with a nonunitary structure formulated on a conventional Hilbert space over the field of complex numbers, including (but not limiting to) all operator theories of gravity on a manifold with non-null curvature, possess the following physical and axiomatic inconsistencies:

I) lack of invariant units of space, time, energy, etc., with consequentially impossible applications to real measurements as well as loss of the entire axiomatic structure;

II) lack of preservation of the original Hermiticity in time, with consequential absence of physically acceptable observables;

III) general violation of probability and causality laws;

IV) lack of invariance of conventional and special functions and transforms used in data elaborations;

V) lack of uniqueness and invariance of numerical predictions;

VI) General violation of the superposition principle with consequential inapplicability to composite systems;

VII) General violation of Mackey imprimitivity theorem with consequential violation of Galilei's and Einstein's special relativities.

All classical noncanonical theories formulated on conventional spaces over conventional fields, including (but not limited to) all classical theories of gravity formulated on a manifold with non-null curvature, are afflicted by corresponding physical and axiomatic inconsistencies which prevent their consistent representation of physical reality.

The above physical inconsistencies have been identified to occur for numerous theories, such as (see [1g] for details and literature): 1) Dissipative nuclear models with imaginary potentials; 2) Statistical models with external collisions terms; 3) q-, k- and *-deformations; 4) Certain quantum groups (evidently those with a nonunitary structure); 5) Weinberg's nonlinear theory; 6) All known theories of classical and quantum gravity on curved manifolds; 7) All known supersymmetric theories; 8) All known Kac-Moody theories; and other theories.

In this note we point out apparently for the first time that, despite an undeniable *mathematical* beauty, the *physical* inconsistencies of Theorem 1 also apply to current, classical and operator formulations of *string theories* (see, e.g., Refs. [2] and vast literature quoted

therein), because of various reasons, such as:

A) The known nonunitary character of string theories formulated via the Beta function according to Veneziano and Suzuki;

B) The more recent supersymmetric formulations of string theories, because it implies the exiting from Lie's axioms (1) with consequential noninvariances (3);

C) Recent formulations of string theories on curved manifolds (see, e.g., [2b]) because they imply the additional, independent, rather serious inconsistencies mentioned earlier.

The only way known to this author to resolve these inconsistencies is that of reformulating string theories in such a way to *regain the original invariances (2) in their totality*. In turn, the only way known to this author to achieve such an objective is the use of the new formalism of *hadronic mechanics* (see Ref.s [3,4,5] and large literature quoted therein).

The invariant reformulations of *closed-isolated string systems* requires the isomathematics used in the *isotopic branch of hadronic mechanics*, and are here called *isotopic string theories* (IST). Isomathematics is essentially based on lifting the conventional n-dimensional unit $I = \text{diag.}(1, 1, \dots, 1)$ into a (nonsingular) $n \times n$ -dimensional quantity \hat{I} , called *isounit* (where the prefix "iso-" means "axiom-preserving" character). In particular, \hat{I} possesses an unrestricted functional dependence on time t , coordinates r , momenta p , wavefunctions ψ , and any other needed variable. Jointly, the conventional associative product $A \times B$ among generic quantities A , B (such as numbers, vector fields, operators, etc.) must be lifted into a form, called *isoproduct*, which admits \hat{I} as the new right and left unit,

$$\begin{aligned} I = \text{diag.}(1, 1, \dots, 1) &\rightarrow \hat{I}(t, r, p, \psi, \dots) = U \times U^\dagger = 1/\hat{T} \neq I, \\ A \times B &\rightarrow A \hat{\times} B = A \times \hat{T} \times B, \\ \hat{I} \hat{\times} A &= A \hat{\times} \hat{I} = A. \end{aligned} \tag{4}$$

The explicit construction of the IST then essentially requires:

a) The identification of the background canonical-unitary theory, generally consisting of RQM on a Minkowski space $M = M(x, \eta, F)$ with spacetime coordinates x and metric $\eta = \text{diag.}(1, -1, -1, -1)$ on the reals $F = F(n, +, \times)$;

b) The identification of the (*noncanonical or*) *nonunitary transform* of η into the new metric $g(x)$ of the considered string theory, $g(x) = U \times \eta \times U^\dagger$;

c) The assumption of the isounit $\hat{I} = U \times U^\dagger \neq I$;

and the reconstruction of the totality of the conventional formalism into such a form to admit \hat{I} as the correct left and right new unit, with no exception known to this author.

This implies the lifting of [3f]: conventional numbers and fields into the *isonumbers* \hat{c} and *isofields* $\hat{C}(\hat{c}, \hat{+}, \hat{\times})$; conventional differential calculus into the isodifferential calculus; conventional Hilbert spaces with related states and inner product into *isohilbert spaces* $\hat{\mathcal{H}}$ with *isostates* and *isoinner product*; conventional eigenvalues equations into *isoeigenvalue equations*, etc., according to the rules

$$\hat{c} = U \times c \times U^\dagger = c \times \hat{I}, \hat{c}_1 \hat{+} \hat{c}_2 = (c_1 + c_2) \times \hat{I}, \hat{c}_1 \hat{\times} \hat{c}_2 = (c_1 \times c_2) \times \hat{I},$$

$$\begin{aligned}
\hat{r}^k &= r^k \times \hat{I}, \hat{d}\hat{r}^k = \hat{I}_i^k \times d\hat{r}^i, \hat{\partial}/\hat{\partial}\hat{r}^k = \hat{T}_k^i \times \partial/\partial r^i, \hat{\partial}\hat{r}^i/\hat{\partial}\hat{r}^j = \hat{\delta}_k^i = \delta_k^i \times \hat{I}, \\
|\hat{\phi}\rangle &= U \times |\phi\rangle, U \times \langle\phi| \times |\psi\rangle \times U^\dagger = \langle\hat{\phi}| \hat{\times} |\hat{\psi}\rangle \times \hat{I}, \\
U \times H \times |\phi\rangle &= \hat{H} \hat{\times} |\hat{\phi}\rangle = U \times E \times |\phi\rangle = \hat{E} \hat{\times} |\hat{\phi}\rangle = E \times |\hat{\phi}\rangle, \hat{H} = U \times H \times U^\dagger. \quad (5)
\end{aligned}$$

The transformation theory of the new string theory is then strictly *nonunitary*. However, for consistency, all possible nonunitary transforms must be rewritten as *isounitary transforms* on $\hat{\mathcal{H}}$ over \hat{C} , with consequential regaining of all original invariances (2) [3g], e.g.,

$$\begin{aligned}
V \times V^\dagger &= \hat{I} \neq I, V = \hat{V} \times \hat{T}^{1/2}, V \times V^\dagger = \hat{V} \hat{\times} \hat{V}^\dagger = \hat{V}^\dagger \hat{\times} \hat{V} = \hat{I}, \\
\hat{I} &\rightarrow \hat{V} \times \hat{I} \times \hat{V}^\dagger = \hat{I}' = \hat{I}, \\
\hat{A} \hat{\times} \hat{B} &\rightarrow \hat{V} \hat{\times} (\hat{A} \hat{\times} \hat{B}) \hat{\times} \hat{V}^\dagger = V \times A \times V^\dagger \times V \times B \times V^\dagger = \hat{A}' \hat{\times} \hat{B}', \\
\hat{H} \hat{\times} |\hat{\psi}\rangle &= \hat{E} \hat{\times} |\hat{\psi}\rangle \rightarrow \hat{V} \hat{\times} \hat{H} \hat{\times} |\hat{\psi}\rangle = \hat{V} \hat{\times} \hat{H} \hat{\times} \hat{V}^\dagger \hat{\times} \hat{V} \hat{\times} |\hat{\psi}\rangle = \hat{H}' \hat{\times} |\hat{\psi}'\rangle = \\
&\hat{V} \hat{\times} \hat{E} \hat{\times} |\hat{\psi}\rangle = \hat{E}' \hat{\times} |\hat{\psi}'\rangle, \hat{E}' = \hat{E}, \quad (6)
\end{aligned}$$

As one can see, the use of the isotopic formalism of hadronic mechanics implies the full regaining of the *numerical invariance* of the isounit, isoproduct and isoeigenvalues, thus regaining the necessary conditions for physical applications. It is easy to prove that *isohermicity coincides with the conventional Hermiticity*. As a result, all conventional observables of unitary theories remain observables under their isotopic lifting. The preservation of Hermiticity-observability in time is then ensured by the above isoinvariances. Detailed studies conducted in Ref. [3g] then establish the resolution of all inconsistencies of Theorem 1.

The primary reason for the consistency is the full regaining of the Lie axioms. Again under nonunitary transforms submitted to isotopic reformulation, we have the rules

$$\begin{aligned}
U \times e^X \times U^\dagger &= \hat{e}^{\hat{X}} = (e^{\hat{X} \times \hat{T}}) \times \hat{I} = \hat{I} (e^{\hat{T} \times \hat{X}}), \\
\hat{A}(\hat{w}) &= \hat{U} \hat{\times} \hat{A}(\hat{0}) \hat{\times} \hat{U}^\dagger = \hat{e}^{i\hat{X} \hat{\times} \hat{w}} \hat{\times} \hat{A}(\hat{0}) \hat{\times} \hat{e}^{-i\hat{w} \hat{\times} \hat{X}} = e^{(\hat{X} \times w) \times \hat{T}} \times \hat{A}(\hat{0}) \times e^{-i\hat{T} \times (\hat{w} \times \hat{X})}, \\
i\hat{d}\hat{A}/\hat{d}\hat{w} &= \hat{A} \hat{\times} \hat{X} - \hat{X} \hat{\times} \hat{A} = \hat{A} \times \hat{T} \times \hat{X} - \hat{X} \times \hat{T} \times \hat{A} = [\hat{A}, \hat{X}], \\
\hat{e}^{i\hat{X} \hat{\times} \hat{w}} &= [\hat{e}^{-i\hat{w} \hat{\times} \hat{X}}]^\dagger. \quad (7)
\end{aligned}$$

As one can see, the regaining of Lie's theory is so strong that the conventional and isotopic theories coincide at the abstract, realization-free level. In fact, the Lie-Santilli isotopic theory [3,4,5] can be formulated by essentially "putting the hat" to the *totality* of symbols and operations of the conventional formulation of Lie's theory or, equivalently, by keeping the conventional formulation and subjecting *all* conventional symbols to the more general isotopic interpretation.

It should also be recalled that, since I and \hat{I} are topologically equivalent, the isotopic images of all Lie groups are locally isomorphic to the original groups. This implies the

preservation of the exact validity for nonunitary string theories of the fundamental space-time symmetries, such as the Poincaré symmetry, Einstein's special relativity and well as relativistic quantum mechanics (see Refs. [3h,3j] for details).

The above reformulation implies a new representation of classical and operator gravity via an *isoflat geometry* (i.e., a geometry flat on isospaces over isofields), introduced by this author under the name of *isominkowskian geometry* [3j], which is defined on isospaces $\hat{M} = \hat{M}(\hat{x}, \hat{\eta}\hat{F})$ with isocoordinates $\hat{x} = x \times \hat{I}$ and isometric $\hat{\eta} = \hat{\eta}(x, v, a, \psi, \dots)$ on the isoreals $\hat{F} = \hat{F}(\hat{n}, \hat{+}, \hat{\times})$.

The new classical and operator formulation of gravity was first proposed in Ref. [3i] (see memoir [3j] for a more recent treatment), in which gravity is merely embedded in the *unit* of conventional, classical and operator Minkowskian theories via the factorization of all possible Riemannian metrics $g(x) = \hat{T}_{grav} \times \eta$ and the assumption of the gravitational isounit $\hat{I}_{grav} = \hat{T}_{grav}^{-1}$. Since curvature is evidently contained in the term $\hat{T}_{grav}(x)$, the assumption for fundamental unit of the *inverse*, $\hat{I}_{grav} = \hat{T}_{grav}^{-1}$, evidently eliminates curvature at the abstract level. Moreover, \hat{T} is necessarily positive-definite (from the local Minkowskian character of Riemann). As a result, gravity is formulated for the first time under a universal *invariance* (rather than "covariance") isomorphic to the Poincaré symmetry [3h].

Also, the isominkowskian geometry is a symbiotic unification of the Minkowskian and Riemannian geometries because, on one side, it is locally isomorphic to the Minkowskian geometry while, on the other side, it preserves all the machinery of Riemann (such as covariant derivatives, Christoffel's symbols, etc.), although formulated via the isodifferential calculus (because the isometric depends on x).

One obtains a new *classical iso-gravity* (CIG) which preserves the conventional Einstein-Hilbert (and other) field equations. Yet, the abandonment of the notion of curvature (which is necessary to resolve the inconsistencies of Theorem 1) permits the formulation of gravity as an *isocanonical theory* under the universal isopoincaré symmetry, thus resolving the inconsistencies of Theorem 1. Similarly, one obtains a new *operator iso-gravity* (OIG) which coincides at the abstract level with RQM, including the operator version of the universal isopoincaré invariance, thus resolving the inconsistencies of Theorem 1 at the operator level too.

The reconstruction of gravity on an isoflat space has permitted the achievement of an axiomatically consistent grand unification of electroweak and gravitational interactions first proposed in Ref. [3k] (see [3l] for more details) under the name of *iso grand-unification* (IGU), in which gravity is embedded in the *unit* of $U(2) \times U(1)$. This grand unification is evidently available to string theories in isotopic reformulation.

The explicit formulation of IST is elementary. Consider, for instance, Ref. [2b]. Its basic assumption is metric (1.3), p. 50, in a curved space $g = (1, -a^2 \times \delta_j^i)$. It is evident that such a metric is a noncanonical image of the conventional Minkowski metric $g = U \times \eta \times U^t, U = \text{diag.}(1, a \times \delta_j^i)$. The isotopic reformulation of such a theory then requires the use of the isounit $\hat{I} = (1, a^2 \times \delta_j^i)$ and the reconstruction of the totality of the formalism of Ref.

[2b] with respect to \hat{I} , including numbers, fields, spaces, algebras, functional analysis, etc. Invariance and the resolution of the inconsistencies of Theorem 1 then follow.

Note that the construction implies a mere *reformulation* of conventional string theories without altering the results.

As an incidental note, it should be mentioned that *all papers on the isotopic branch of hadronic mechanics prior to the appearance of the isodifferential calculus [3f] in 1996 (beginning with the articles by this author) generally have no physical applications*. This is due to the lack of invariance of the basic dynamical equations because they are formulated via the conventional differential calculus, even though the rest of the theories is formulated on isospaces over isofields [3g].

For the case of *open-irreversible string theories*, that is, strings interacting with systems considered as external, we need the more general *genotopic branch of hadronic mechanics* with a Lie-admissible structure first proposed by this author in his Ph. D. studies, Ref. [3b] of 1967, as a (p, q) -parametric deformation of quantum mechanics, $(A, B) = p \times A \times B - q \times B \times A$, and in Ref. [3c] of 1978 as a (P, Q) -operator deformation, $(A, B) = A \times P \times B - B \times Q \times A$, where the prefix "geno" now indicates an "axiom-inducing" character.

Lie-admissible theories reached mathematical maturity only recently in memoir [3f] of 1996 and invariance of physical formulations in the subsequent Ref. [3n] thanks to the advent of the *genodifferential calculus* of the preceding memoir [3f]. Therefore, *all papers on Lie-admissible theories prior to Refs. [3f, 3n] (beginning with the papers by this author) generally have no physical applications* because of the lack of invariance of the basic dynamical equations due to their formulation via the conventional differential calculus.

The construction of open-irreversible *genotopic string theories* (GTS) requires *two different nonunitary systems and related transforms*, one for the forward direction of time $>$ and one for the backward direction $<$. Consequently, GST need *two* generalized units called *genounits*, *two* products called *genoproducts* and corresponding dual formalism, again, one per each direction of time, along the following main lines

$$\begin{aligned} V \times V^\dagger &\neq I, W \times W^\dagger \neq I, \\ V \times W^\dagger &= \hat{I}^> = 1/\hat{S}, \hat{A} > \hat{B} = \hat{A} \times \hat{S} \times \hat{B}, \hat{I}^> > \hat{A} = \hat{A} > \hat{I}^> = \hat{A}, \\ W \times V^\dagger &= {}^<\hat{I} = 1/\hat{R}, \hat{A} < \hat{B} = \hat{A} \times \hat{R} \times \hat{B}, {}^<\hat{I} < \hat{A} = \hat{A} < {}^<\hat{I} = \hat{A}, \\ \hat{A} &= \hat{A}^\dagger, \hat{B} = \hat{B}^\dagger, \hat{R} = \hat{S}^\dagger. \end{aligned} \tag{8}$$

The above elements must then be completed, for necessary reasons of consistency, with the forward and backward genofields, genospaces, genodifferential calculus, genogeometries, etc. [3f, 3h, 3r].

The procedure yields the following Lie-admissible realization of Lie's axioms (1) at a fixed value of the parameter w (thus without its ordering and by omitting the ordering in the individual generators for simplicity of notation) [3c, 3d]

$$\hat{A}(\hat{w}) = e_{>}^{i\hat{X} \times \hat{w}} > \hat{A}(\hat{0}) < e_{<}^{-i\hat{w} \times \hat{X}} = [e^{(i\hat{X} \times \hat{w}) \times \hat{S}} \times \hat{I}^>] \times \hat{S} \times \hat{A}(\hat{0}) \times \hat{R} \times [{}^<\hat{I} \times e_{<}^{-i\hat{R} \times (\hat{w} \times \hat{X})}],$$

$$i\hat{d}\hat{A}/\hat{d}\hat{w} = (\hat{A}, \hat{X}) = \hat{A} < \hat{X} - \hat{X} > \hat{A} = \hat{A} \times \hat{R} \times \hat{X} - \hat{X} \times \hat{S} \times \hat{A},$$

$$\hat{X} = \hat{X}^\dagger, \hat{R} = \hat{S}^\dagger. \quad (9)$$

It should be stressed that structures (9) merely provide a *broader realization* of the original Lie axioms (1), which is the basic theme of hadronic mechanics [3]. In fact, the original Lie axioms (1) have a *bimodular associative structure*, with a modular-associative action to the right and a separate one to the left. These actions do not need to be given by the simplest conceivable realization of current use, because the isotopic realization is equally admissible. The lack of necessary identity of the two modular-isotopic actions then yields genotopic structures (9), provided that conjugation (1c) is verified.

In Ref. [3a] of 1956 this author (then in high school) showed how the "ethereal wind" used at the time to dismiss the existence of a universal substratum (or ether) had no solid physical foundations because said universal substratum is needed not only to propagate electromagnetic waves, but also for the very existence of elementary particles (such as the electrons), which are "oscillations-vibrations" of the same medium. The author was unaware at the time that, over twenty years earlier, Schroedinger had proved that the variable "x" in Dirac's equations for the *free* electron describes precisely an oscillation which can only be that of the universal; substratum. The transversal character of electromagnetic waves demands that the universal substratum be a rigid medium. In short, the view presented in Ref. [3a] is that *space is completely full while matter is completely empty*. When matter is moved we merely transfer the oscillations of space from one region to another, thus without any possible "ethereal wind".

The genotopic reformulation of string theories permits quantitative studies along the view of Ref. [3a]. In fact, *GST permit an axiomatically consistent and invariant reduction of our macroscopic irreversible physical reality to the most elementary entities in the universe, the vibrations of the universal substratum under open-nonconservative conditions*.

As one can see, Lie-admissible structures (9) are *structurally irreversible* in the sense that they are *irreversible* for all possible conventional, reversible Hamiltonians. This is precisely what needed for a serious study of irreversibility because all action-at-a-distance interactions are well known to be reversible, while physical reality is irreversible. Irreversibility should therefore be represented with anything *except the Hamiltonian*. This is along the historical teaching by Lagrange and Hamilton who represented irreversibility via *the external terms* in their celebrated equations, which terms have been "truncated" in the literature of this century. The use of two different generalized units for the representation of irreversibility appears to be preferable over other attempts, evidently because it assures invariance.

Interested readers can then find in Refs. [3f,3n] the invariant genotopic formulation of: Newton's equations with contact-nonhamiltonian forces; the true Hamilton equations (those with external terms); quantization; and quantum mechanics. When applied to string theories, these formulations then permit the indicated reduction of our classical irreversibility to the most elementary possible entities, open-nonconservative vibrations of space.

Physics is a science that will never admit "final theories". By no means GST's are the

most general ones. For completeness we mention the existence of the *hyperstructural branch of hadronic mechanics* [3f,3g] whose main characteristic is that of being *multi-valued* with *hyperunits and hyperproducts*,

$$\begin{aligned}
\hat{I}^{\triangleright} &= \{\hat{I}_1^{\triangleright}, \hat{I}_2^{\triangleright}, \hat{I}_3^{\triangleright}, \dots\} = 1/\hat{S}, \\
A > B &= \{A \times \hat{S}_1 \times B, A \times \hat{S}_2 \times B, A \times \hat{S}_3 \times B, \dots\}, \hat{I}^{\triangleright} > A = A > \hat{I}^{\triangleright} = A \times I, \\
{}^{\triangleleft}\hat{I} &= \{{}^{\triangleleft}\hat{I}_1, {}^{\triangleleft}\hat{I}_2, {}^{\triangleleft}\hat{I}_3, \dots\} = 1/\hat{S}, \\
A < B &= \{A \times \hat{R}_1 \times B, A \times \hat{R}_2 \times B, A \times \hat{R}_3 \times B, \dots\} {}^{\triangleleft}\hat{I} < A = A < {}^{\triangleleft}\hat{I} = A \times I, \\
A &= A^{\dagger}, B = B^{\dagger}, \hat{R} = \hat{S}^{\dagger}.
\end{aligned} \tag{10}$$

All aspects of the dual Lie-admissible formalism admit a unique, and significant extension to the above hyperstructures, including *hypernumbers and fields, hyperspaces, hyperdifferential calculus, etc.*

The construction of invariant *hyper-string theories* (HST) is then elementary and will be left to the interested reader. Their most salient (and intriguing) feature is that of *permitting the existence of a multi-valued universe beginning at the most elementary level of nature, and in a way compatible with our three-dimensional sensory perception.*

A suggestive illustration is given by *sea shells* [3r]. All their possible *shapes* can indeed be fully represented in the conventional Euclidean space corresponding to our three Eustachian tubes. However, their *evolution in time* cannot be described via the Euclidean axioms, trivially, because sea shells are open-nonconservative-irreversible, while the Euclidean axioms are strictly closed-conservative-reversible. Computer visualizations have shown that the imposition of the latter to the time evolution of the former implies that sea shells first grow in a deformed way and then they crack. Studies have shown that the quantitative representation of the growth in time of sea shells requires at least a *six dimensional space*, i.e., the doubling of each reference axis.

However, we can directly observe sea shells in our hands as being three-dimensional. The only reconciliation of these seemingly dissonant occurrences known to this author is that via hyperformulations [3f]. In fact, the latter are multi-dimensional precisely as needed for the representation of the growth of sea shells. Yet the axioms remain conventional, thus achieving compatibility with our sensory perception.

Specifically, for the case of sea shells we have two-valued hypereuclidean formulations which are fully compatible with our sensory perception because *they are not six-dimensional*, and remain instead fully three-dimensional. After all, there is a dramatic topological difference between a conventionally *six-dimensional* space and our *two-valued three-dimensional* space.

The above example indicates the possibility of reducing open-nonconservative-irreversible *biological* structures to the ultimate vibrations of the universal substratum, thus extending irreversibility from sole physical systems to include biology.

Note that any beliefs in treating the above open-nonconservative-irreversible systems via conventional quantum mechanics implies exiting science, evidently because of the strictly closed-conservative-reversible character of the theory. This is the main motivation for the construction of hadronic mechanics [3].

By no means HST represent the ultimate and most general formulation of string theory. In fact, despite their remarkable generality, hyperformulations (including conventional, isotopic and, genotopic particularizations) cannot consistently represent *antimatter* at the *classical* level. This is due to the sole existence of *one* quantization channel, as a consequence of which *the operator images of classical iso, geno and hyper-structures cannot yield charge conjugated antiparticles, but only particles with the wrong sign of the charge.*

The above occurrence is only a symptom of what can be safely claimed to be the biggest unbalance of theoretical physics of this century: the treatment of matter at all possible levels, from Newton to second quantization, while antimatter is solely treated at the level of *second* quantization.

After a laborious search, the only *classical* representation of *antimatter* this author could identify is that characterized by the following map, called *isoduality*, here expressed for a generic quantity A, as well as for the underlying spaces and fields [30],

$$A(x, v, \psi, \dots) \rightarrow A^d = -A^\dagger(-x^\dagger, -v^\dagger, -\psi^\dagger, \dots) \quad (11)$$

which characterizes the *isodual branches of hadronic mechanics* [3g].

The above map is mathematically nontrivial, e.g., because it implies the first known *numbers with negative units and norm* [3e]. Physically, the map is also nontrivial because it implies an isodual image of our universe which coexists with our own, yet it is distinct from it. Universes interconnected by isoduality are then *anti-isomorphic* to each others, as it is the case for the charge conjugation. In fact, isoduality is equivalent to charge conjugation at the level of second quantization [30]. In particular, *all physical quantities (and not only the charge) interconnected by isoduality have opposite signs, although referred to units also with opposite signs.* For instance, time for an isodual antiparticle is *negative*, although referred to a *negative unit of time* -1 sec, thus being as causal as our conventional positive time referred to the conventional positive unit +1 sec. The kronecker product of a universe and its isodual is called *isoselfdual* in the sense of coinciding with its isodual image (see [30] for details).

Isotopic, genotopic and hyper-string theories therefore admit isodual images whose explicit construction is left to the interested reader for brevity. Their significance is not only restricted to a *classical* reduction of *antimatter* to vibrations at the ultimate possible level of the universe, but also that of permitting a novel cosmology, here called *isoselfdual hyperstring cosmology* (IHSC) along the lines of Ref. [3m] with rather intriguing characteristics, such as: 1) definition of cosmology inclusive of biological structures (as it should be under the meaning of the term "cosmos"); 2) same amount of matter and antimatter in the universe (as a limit conditions under Lie axiom (1c)); 3) open-irreversible structure of the universe with continuous creation (except for the particular isotopic case); 4) universal isopoincaré *invariance* inclusive of gravitation in isominkowskian reformulation [3l]; 5) lack of need of

the "missing mass", because the average speed of light c of galaxies and quasars in the law $E = m \times c^2$ is *bigger* the speed of light in vacuum c_0 when including all interior gravitational problems [3m]; 6) considerable reduction of the currently believed size of the universe, because light exits galaxies and quasars already redshifted due to the decrease of its speed within the huge and hyperdense astrophysical chromospheres; 7) possibility of future experimental study whether a far away galaxy or quasar is made up of matter or of antimatter due to the prediction that the photon emitted by antimatter, the *isodual photon*, is repelled by gravity and has new parity properties [3o]; 8) identically null total characteristics of time, mass, energy, etc.; 9) consequential identical topological features of the universe before and after creation; and other intriguing features.

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